

Human Factors Issues and Approaches in the Spatial Layout of a Space Station Control Room, including the Use of Virtual Reality as a Design Analysis Tool

by

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OVERVIEW

Human Factors Engineering support was provided for the 30% design review of the late Space Station *Freedom* Payload Control Area (PCA). The PCA was to be the payload operations control room, analogous to the Spacelab Payload Operations Control Center (POCC). This effort began with a systematic collection and refinement of the relevant requirements driving the spatial layout of the consoles and PCA. This information was used as input for specialized human factors analytical tools and techniques in the design and design analysis activities. Design concepts and configuration options were developed and reviewed using sketches, 2-D Computer-Aided Design (CAD) drawings, and immersive Virtual Reality (VR) mockups.

REQUIREMENTS DEFINITION

Identify Guidelines/Constraints

Guidelines, assumptions, constraints, etc. pertaining to this task were identified in order to bound activities and expectations. Areas that were addressed included: schedules, resources for the task and for the procurements, procurement and architectural decisions already made, availability of subject matter experts (SMEs) and reviewers, maturity of PCA operational concepts, deliverables, etc. Information was gathered from a variety of sources. Program documentation was the initial source. SMEs, including lab leads, project offices and chief engineers, and others involved in the definition and development of Payload Operations Integration Center (POIC) operational concepts were interviewed and consulted.

Functional Analyses

The functional analyses subtasks have essentially two components: first, identification and description of the relevant functions and then identification and analysis of the relationships between and among the various functional components. Parameters considered in these activities included the flow of people and materiel. In large part, these flows are driven by the exchange and sharing of information. Thus consideration of the needs, types, and flow of information influenced this design effort. Past and present Spacelab POCC Cadre members were an especially important source for this information. This effort required the development of checklists and questionnaires to standardize the process and help ensure all relevant data was gathered and organized/encoded.

Specific areas of emphasis in this process included adjacency needs, workspace furnishings and accommodations, the "video wall," and documentation. Adjacency related to the degree to which two or more console positions needed to be physically adjacent to each other. Responses included directly adjacent, closely located, eye contact needed; no adjacency requirement. Workspace furnishings and accommodations included work surface (both individual and shared), peripherals (printers, fax machines, etc.), and office equipment (bookcases, whiteboards, file cabinets, etc.). The video wall referred to large video monitors often seen at the "front" of control rooms. Respondants indicated the degree they felt they needed or would refer to a video wall. Finally, documentation referred to the amount of documentation individuals felt they needed personally or could share with an adjacent position as well as the amount of paper transferred among positions both within and outside the PCA.

The units of analysis included the position/console level, teams (Payload Operations Director, Operations

Controller, Data Management, Mission Planning), and the PCA as a whole. Particular attention was paid to the information requirements for each position and/or team. The flow of people, materiel, and information was the focus of this analysis.

DESIGN DEVELOPMENT

During the latter stages of requirements definition, various design concepts and approaches were developed. The requirements definition and analyses accomplished above provided both direction for the design effort and criteria for design analyses. This phase started with the smallest unit of the analysis and built up. That is, consoles were first defined and then used to populate the PCA. PCA layout used the console units as "building blocks" to consider various configuration options. In reality, this is an iterative process, where console layout affects PCA layout options, which in turn affect console layout options. Factored into the PCA layout must also be locations for printers, faxes, document stowage, etc.

Several configurations of the console floor plan layout and large video screens were developed using sketches, scaled templates, and a CAD drawing application. Two basic versions were created. One was the "classic" control room layout with all consoles in parallel rows, facing forward towards the video wall. The other grouped consoles based on inter- and intra- team adjacency and information flow relationships. Each of these basic versions were built in a "landscape" and "portrait" configuration with respect to the rectangular control room floor plan. See figure 1 for a team-driven configuration in landscape mode.

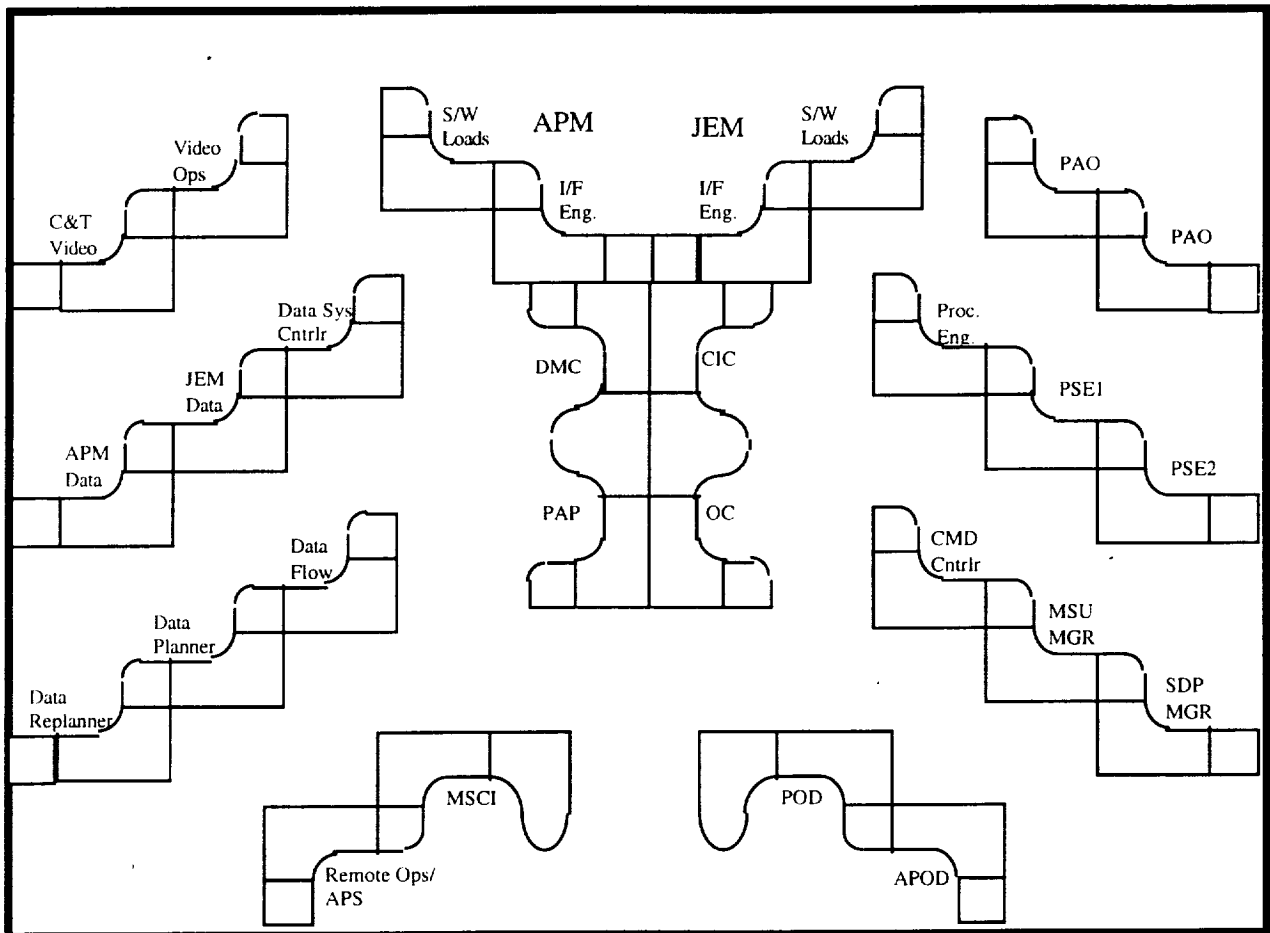
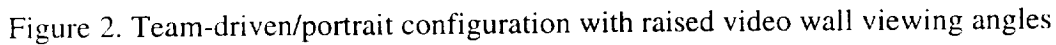


Figure 1. Team-driven/landscape configuration

The various design analysis tools used during this phase included: scaled drawings, 2-D CAD drawings, and immersive VR. The drawings were used to support analyses such as video wall maintenance access, video wall viewing analyses (see figure 2), translation path clearances, adjacency, and information flow and access comparisons.



These analyses helped answer several specific control room architectural questions posed by the architectural engineers (e.g., adequacy of room size, control room and Public Viewing Area relationships, camera secondary structure locations, etc). The most important result, from a Human Factors perspective, was the general change in thinking on what a control room should look like and what should drive its

configuration. The focus on the team and on features that enhance and enable more efficient team operations became more visible and important drivers for control room layout. "Classic" control room layouts with all consoles in parallel rows, facing forward towards the video wall, were viewed as less desirable and less conducive to efficient team operations than a configuration with grouped consoles based on inter- and intra- team operational considerations.

CONCLUSIONS/SUMMARY

This project methodically gathered and developed data and information relevant to address Human Factors related issues in the spatial layout of a control room. These data were then used to drive and later assess the layout design. One of the most important and satisfying results was the apparent elevation of operational considerations as significant drivers in control room spatial layout. Another was the successful use of VR as a design analysis tool. Although the technology is still relatively immature, there are areas where it can be used with some benefit and confidence. It has its limits and users must ensure its validity for a particular application before relying upon the results of its use with confidence (Dittmar and Hale, 1994, Hale and Dittmar, 1994).

REFERENCES

- Dittmar, M. L. and Hale, J. P. (1994). Virtual Reality as a Human Factors Design Analysis Tool for Architectural Spaces - Control Rooms to Space Stations II: Subjective Measures. In Proceedings of the Human Factors Society 36th Annual Meeting (pp.280-283). Santa Monica, CA: Human Factors Society.
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